Data bases of Cryosphere in China

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Abstract:

Data sharing is very important for cryosphere research. This paper introduces main data centers and data repositories on cryoshpere in China. Cold and Arid Regions Science Data Center at Lanzhou focuses on data sharing of cryoshpere, environment and ecosystem of inland basin, desert and desertification, and land surface processes. Chinese National Arctic and Antarctic Data Center focuses on scientific expeditions of China in polar region. The third Pole Environment Database focuses on scientific data sharing on Tibet Plateau. Key data sets on cryosphere are also reviewed by this paper, which include glacier inventory data, glacial lake inventory in HKH region, permafrost maps in China and Tibet Plateau, long time-series near-surface soil freeze/thaw data and long time-series snow cover, snow depth and snow water equivalent.

Keywords: Cryoshpere; Data Sharing; Glacier; Glacial Lake; Permafrost; Snow; Tibet

1 Introduction

Data sharing is very important especially in science community (Nelson, 2009). "Research cannot flourish if data are not preserved and made accessible. All concerned must act accordingly", as stated in the special issue of Nature on data sharing (Editorial Nature, 2009). In China, data sharing is particularly important, because there is no strong culture of data sharing and no rich data available. Data have usually been retained by the scientists themselves rather than deposited in data centers. Fortunately, this situation has significantly improved in recent years (Ran et al., 2007). Several new data centers have been established in addition to the existing World Data Centers in China (Wang and Sun, 2007). A nationwide scientific data-sharing program has been implemented by the Ministry of Science and Technology of China (Xu, 2003), and a consensus has been reached that it is inappropriate to retain data as personal property (Huang and Guo, 2002; Sun and Shi, 2003).

The first data center on cryosphere is World Data Center (WDC) for Glaciology and Geocryology at Lanzhou, which was established in 1988. Since then, science data centers and databases on cryosphere have been established in China support by the Ministry of Science and Technology of China (MOST) and the National Natural Science Foundation of China (NSFC). They have also accumulated experience in data stewardship and been providing services that are believed to be useful for data sharing in China. This paper will introduce main databases and repositories, special datasets and data services on cryosphere in China.

2 Data Bases and Repositories on Cryosphere in China

2.1 Cold and Arid Regions Science Data Center of China, World Data System

Cold and Arid Regions Science Data Center (Figure 1, Table 1) is a new data center which is sponsored by Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI), Chinese Academy of Sciences (CAS) and was integrated on the basis of 1) original WDC for Glaciology and Geocryology at Lanzhou, 2) Digital Heihe River Basin Information System, 3) Subcenter for Resources and Environmental Sciences, CAS, 4) Subcenter of the Earth System Science Data Sharing Platform, and 5) Ecological and Environmental Science Data Center for West China (Li et al. 2008). After assessed by unified criterion of World Data System members, in 2013, Cold and Arid Region Science Data Center joined the WDS as a regular member.

Focusing on both arid region and cryosphere, the goals of this datacenter are as follows: (1) collecting and standardizing the existing environmental and ecological data; (2) providing full and open data access, stewardship and services; (3) formulating effective guidelines for data sharing in China; and (4) facilitating data submissions from the various research projects and other organizations and individuals.

Figure 1 Home page of the Cold and Arid Regions Science Data Center (in Chinese)

Table 1 General information of the Cold and Arid Regions Science Data Center

Name:	Cold and Arid Region Science Data Center
Web site:	http://westdc.westgis.ac.cn (in Chinese), http://card.westgis.ac.cn(in english)
Maintained by:	Cold and Arid Regions Environmental and Engineering Research Institute, CAS
Telephone:	+86 931-4967287
Address:	320 Donggang west road, Lanzhou Gansu 730000, China
E-mail:	westdc@lzb.ac.cn

2.2 Chinese National Arctic and Antarctic Data Center

Chinese Arctic and Antarctic Data Center was established in 1999, under the auspices of the

Ministry of Science and Technology of the People's Republic of China. On March 28, 2002, the original China's polar scientific database system was accepted by MOST and the data center was officially released. In 2003, the system joined “Earth System Science Data Sharing Network" of MOST. In compliance with the principles of the Antarctic Treaty and China's polar expedition data management regulations, this data center is open to the domestic and international scientific community and the general public to provide polar scientific data and other shared services.

The data center (Figure 2, Table 2) focuses on regulating polar scientific data management, sharing and publishing, and covers the following subjects: polar oceanography, polar solar-terrestrial physics, polar ice, polar resources and environmental science, polar biological and ecological, polar geography and geodesy, polar geology and geophysics and polar atmospheric science and other fields. Polar region data integrated 23-Antarctic expedition from 1985 to 2006, twice the Arctic, involving north and south polar expedition data up to 15 terabytes. All data held in the data center is free. In order to ensure quality of data and service, implementation of China polar science data management, including regulations, data specifications and documents, was developed.

Table 2 General information of Chinese National Arctic and Antarctic Data Center

Name:	Chinese National Arctic and Antarctic Data Center
Web site:	http://www.chinare.org.cn/cn/index/ (in Chinese), http://www.chinare.org.cn/en/index/ (in English)
Maintained by:	Polar Research Institue of China
Telephone:	+86 21-58717576
Address:	Shanghai Pudong Jinqiao Road 451, 200136
E-mail:	nadc@pric.gov.cn

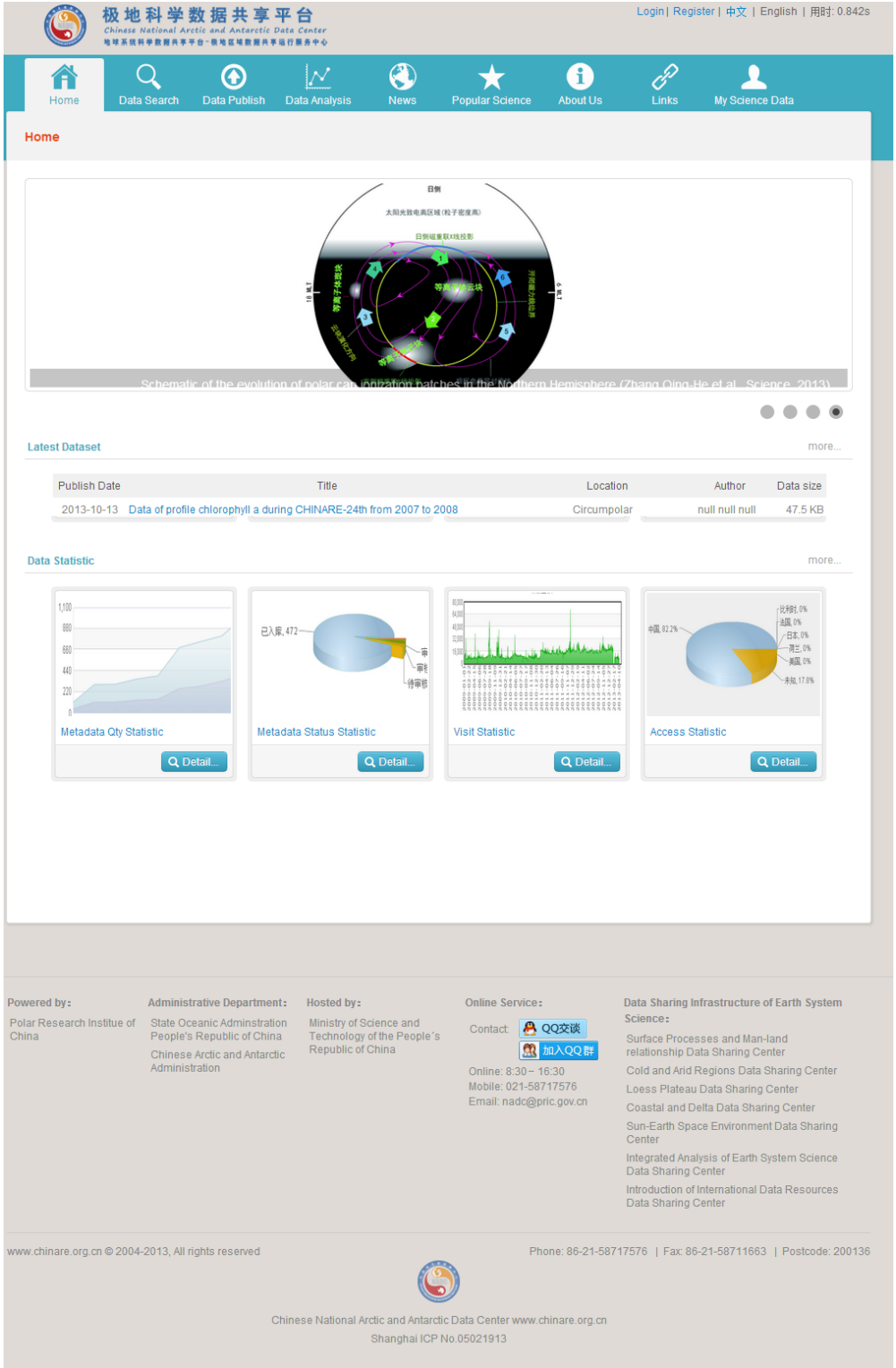

Figure 2 Home page of the Chinese National Arctic and Antarctic Data Center

2.3 Third Pole Environment Database

Third Pole Environment Database was established by the Institute of Tibetan Plateau Research, Chinese Academy of Sciences. This data base (Figure 3, Table 3) was specifically designed for data

preservation, management and service for the Tibet Plateau science data. Aiming at strengthening Tibet research, it provides a unified access point for sharing scientific data relevant to Tibetan research.

The tasks of the data base include：

- Establishing data standards and norms for projects relevant to Tibetan research;
- Collating data to ensure data quality and security;
- Responsible for quality review;
- Responsible for data management and services;
- Assisting scientists in processing and exploiting data.

Table 3 General information of Third Pole Environment Database

Name:	Third Pole Environment Database
Web site:	http://www.tpedatabase.cn/ (in Chinese)
Maintained by:	Institute of Tibetan Plateau Research Chinese Academy of Sciences
Telephone:	+86 10-84097029
Address:	Building 3, 16# Lincui Road, Chaoyang District, Beijing 100101
E-mail:	sdb@itpcas.ac.cn

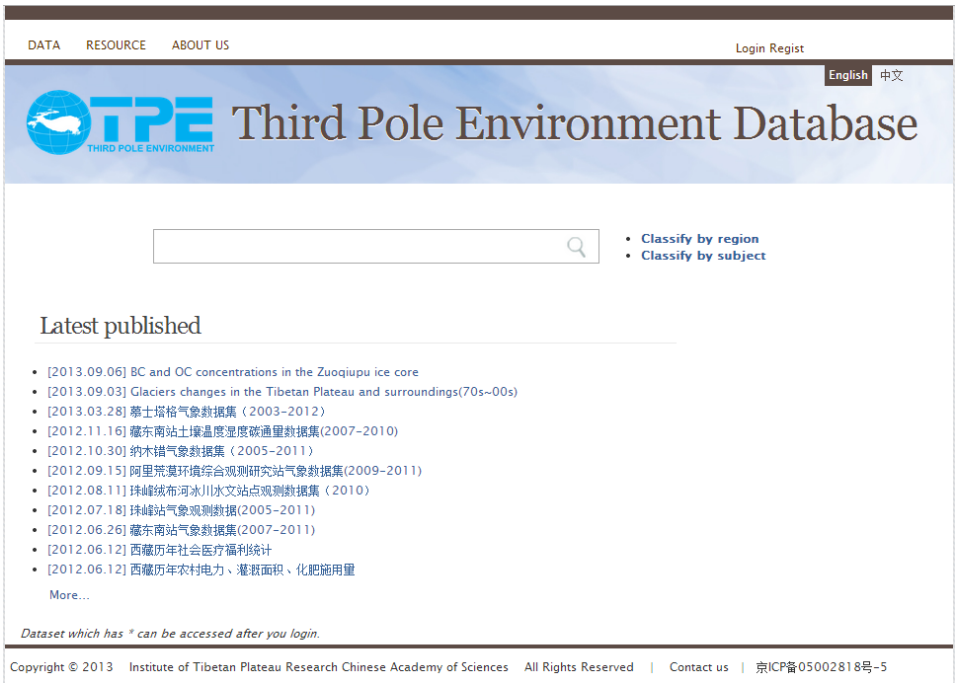

Figure 3 Home page of Third Pole Environment Database

2.4 Chinese Glacier Resources and Change Information System

Glacier is sensitive to global climate change, and low-latitude mountain glaciers are also important for arid region agricultural irrigation. Glaciers inventory is an important basic work for glacier change and climate change research.

The first glacier inventory of China based on topographic maps and aerial photos was begun from 1978 and completed in 2002, in which background data on glacier resources and baselines for glacier change were obtained. After that, to investigate glacier status around 2005, the second glacier inventory which was entitled "Investigation on Glacier Resources and Their Changes in China" funded by MOST during 2006 and 2011 was launched. Satellite images and field investigation were both used in this inventory for glacier mapping and accuracy validation. The key attentions were put on typical glaciers or glacier regions.

On the basis of out coming data, a data management and sharing information system (Figure 4, Table 4) was established in 2011. The data sets ready for sharing include: 1) satellite images, 2)

DEMs, 3) glacier inventory data, 4) glacial lake inventory in the Himalaya region; 5) glacier distribution maps on typical glaciers or glacial region in different periods, 6) hydrologic and meteorological observation data sets, and 7) mass balance datasets.

Table 4 General information of the Chinese Glacier Resources and Change Information System

Name**:**	Chinese Glacier Resources and Change Information System
Web site**:**	http://westdc.westgis.ac.cn/glacier (in Chinese)
Maintained by**:**	Cold and Arid Regions Environmental and Engineering Research Institute, CAS
Tel:	+86 931-4967287
Address:	320 Dongang West Road, Lanzhou Gansu 730000, China
E-mail**:**	liusy@lzb.ac.cn

Figure 4 Home page of “Chinese Glacier Resources and Change Information System” (in Chinese)

2.5 Data Information System of Permafrost Environment Investigation over the Qinghai-Tibet Plateau

Comprehensive and systematic permafrost background data play an import role in the Tibet Plateau permafrost research. The project “Investigation of permafrost and its environment over the Qinghai-Xizang(Tibet) Plateau” was funded by the Ministry of Science and Technology of China. Targeting to share the project generated data, the “Data Information System of Permafrost Environment Investigation over the Qinghai-Tibet Plateau”(Figure 5) was established in 2012, including existing frozen soil data, drilling data, geophysical investigation data, soil profiles, vegetation investigation data, frozen soil active layer data, flux data, ground temperature data,

meteorological observation data and spatial data, in typical investigated permafrost areas and over the entire plateau.

Table 5 General information of information system for the Data Information System of Permafrost Environment Investigation over the Qinghai-Tibet Plateau

Name:	Data Information System of Permafrost Environment Investigation over the Qinghai-Tibet Plateau
Web site:	http://pf.crs.ac.cn/ (in Chinese)
Maintained by:	Cold and Arid Regions Environmental and Engineering Research Institute, CAS
Tel:	+86 931-4967287
Address:	320 Dongang West Road, Lanzhou Gansu 730000, China
E-mail:	linzhao@lzb.ac.cn

Figure 5 Screenshot of the Data Information System of Permafrost Environment Investigation over the Qinghai-Tibet Plateau (in Chinese)

3 Featured Datasets on Cryosphere in China

3.1 Glacier Inventory dataset of China

"Glacier Inventory of China" was compiled according to the instruction of the World Glacier Inventory (WGI) and was a part of WGI. It has cost more than 20 years to complete this project from 1979 to 2002.The whole inventory contains all the glacialized areas in China, which includes the Qilian Mountains, Kunlun Mountains, Altay Mountains, Tianshan Mountains, Pamir Mountains, Karakorum Mountains, Kunlun Mountains, Qinghai-Xizang Plateau Interior Area, Changjiang (Yangtze River) Drainage Basin, Lancang River Drainage Basin, Nujiang River Drainage Basin, Indus and Ganga Drainage Basins within the territory of China, and consists of twelve volumes of 21 books. Each book contains attribute tables of glacier inventory, maps of glacier distribution, explanations, distribution and variation of glacier and its related features (Shi, 2005).

The China Glacier Inventory database, as shown in Figure 6, was developed based on the 21 glacier inventory books and glacier distribution maps using database and GIS technologies. It contains China glacier inventory database, vector maps of glacier distribution, and comprehensive statistics of glacier in China. The whole database contains 46,394 glacier records and 33 glacier attribute items and 5 drainage basins, among which 142 glacier are locate in Pakistan. The total number of glacier is 46,252 with area 59,403.12 km^2 (Wu and Li, 2004).

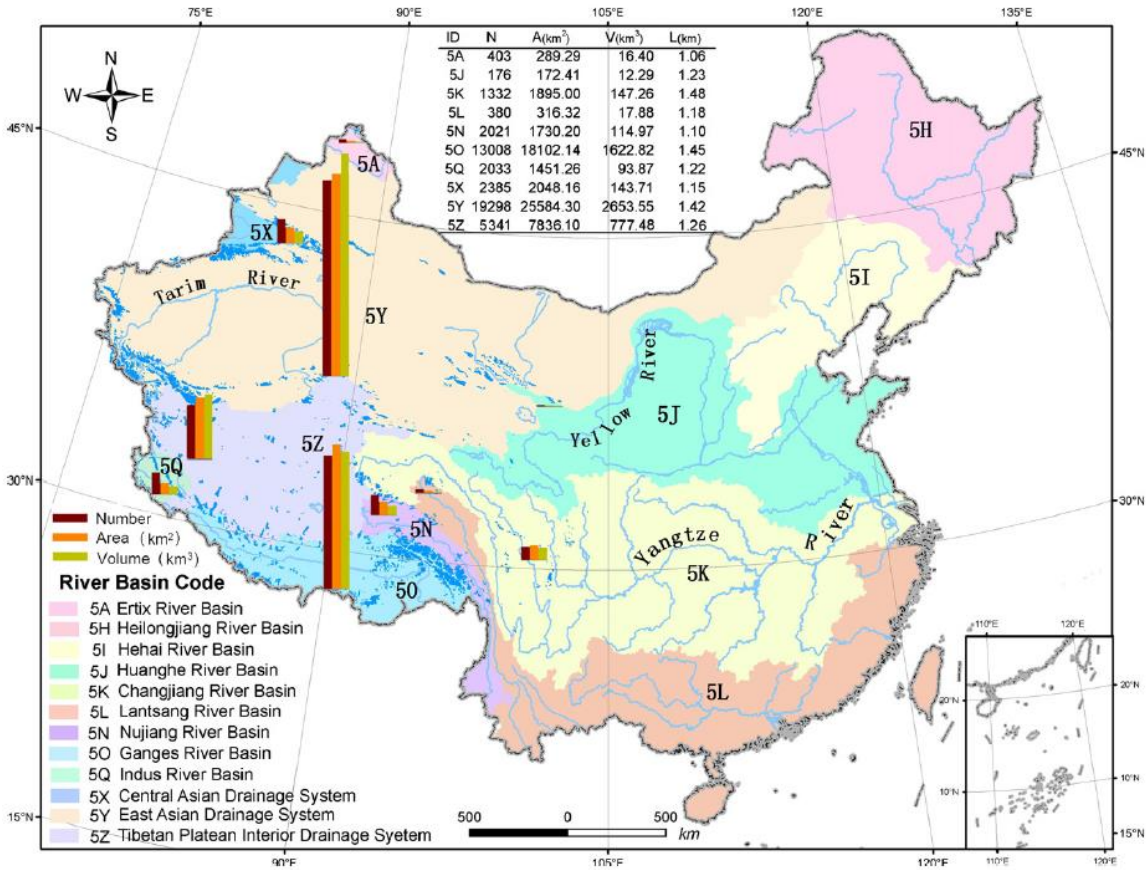

Figure 6 Distribution map of glaciers in China (Li et al. 2008)

(The vertical bars denote the magnitudes of glacier numbers, total area and total volume in each drainage system; the table shows the river basin code (ID), and statistics of glacier numbers (N), total area (A), and total volume(V))

3.2 Glacial Lake Dataset in the Hindu Kush-Himalayan (HKH) Region

The Hindu Kush-Himalayan (HKH) and Tibet Plateau region is one of the most heavily glaciated areas in the world outside the polar region. It has been widely recognized that global climate change is causing the shrinkage or retreat of glaciers in this region. This is leading to the formation and expansion of glacial lakes, which could in turn lead to an increase in the number of glacial lake outburst floods (GLOFs).In the last half century, several glacial lakes have developed and burst in the Hindu Kush-Himalayas, some of which have caused considerable damage across international borders.

In order to obtain the basic information for glacial lake risk assessment, disaster prevention and mitigation, glacial lake inventory based on satellite images has been carried out by International Centre for Integrated Mountain Development (ICIMOD) and CAREERI/CAS. In this inventory, 20,485 lakes have been registered in the HKH region. Among these lakes, 20,204 lakes are glacial lake, and 296 lakes are non-glacial lakes. The distribution map of glacial lake is shown in Figure 7.

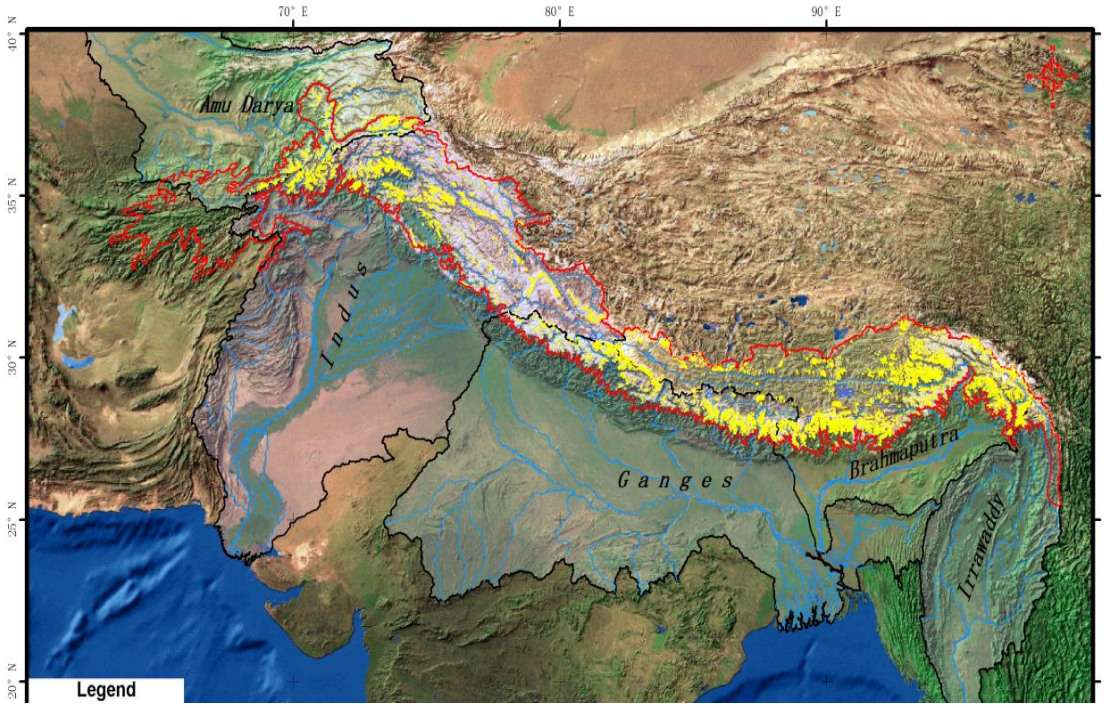

Figure 7 Glacial lakes distribution map in the HKH region

3.3 Existing Permafrost maps in China

Many permafrost maps in China have been compiled since the early 1960s. The scales of these maps range from the local (1:600 000) to the regional scale (1:10 000 000). These maps provide good summary of previous permafrost studies in China. All of these data sets were digitized and then currently can be available in the Environmental and Ecological Science Data Center for West China (WestDC) (Li et al., 2011) (http://westdc.westgis.ac.cn). These maps represent the best understandings at the time in terms of the distribution of permafrost in China and its changes over the

past century.

- Map of Snow, Ice and Frozen Ground in China (Shi and Mi, 1988), Figure 8.
- Frozen Ground Map of Qinghai-Tibet Plateau (Li and Cheng, 1996), Figure 9.
- The China subset of the Circum-Arctic Map of Permafrost and Ground Ice Conditions (Brown et al., 1997), Figure 10.
- The Map of Geocryological Regionalization and Classification in China (Qiu et al., 2000), Figure 11.
- Map of Glaciers, Frozen Ground and Deserts in China (CAREERI/CAS, 2005),Figure 12.

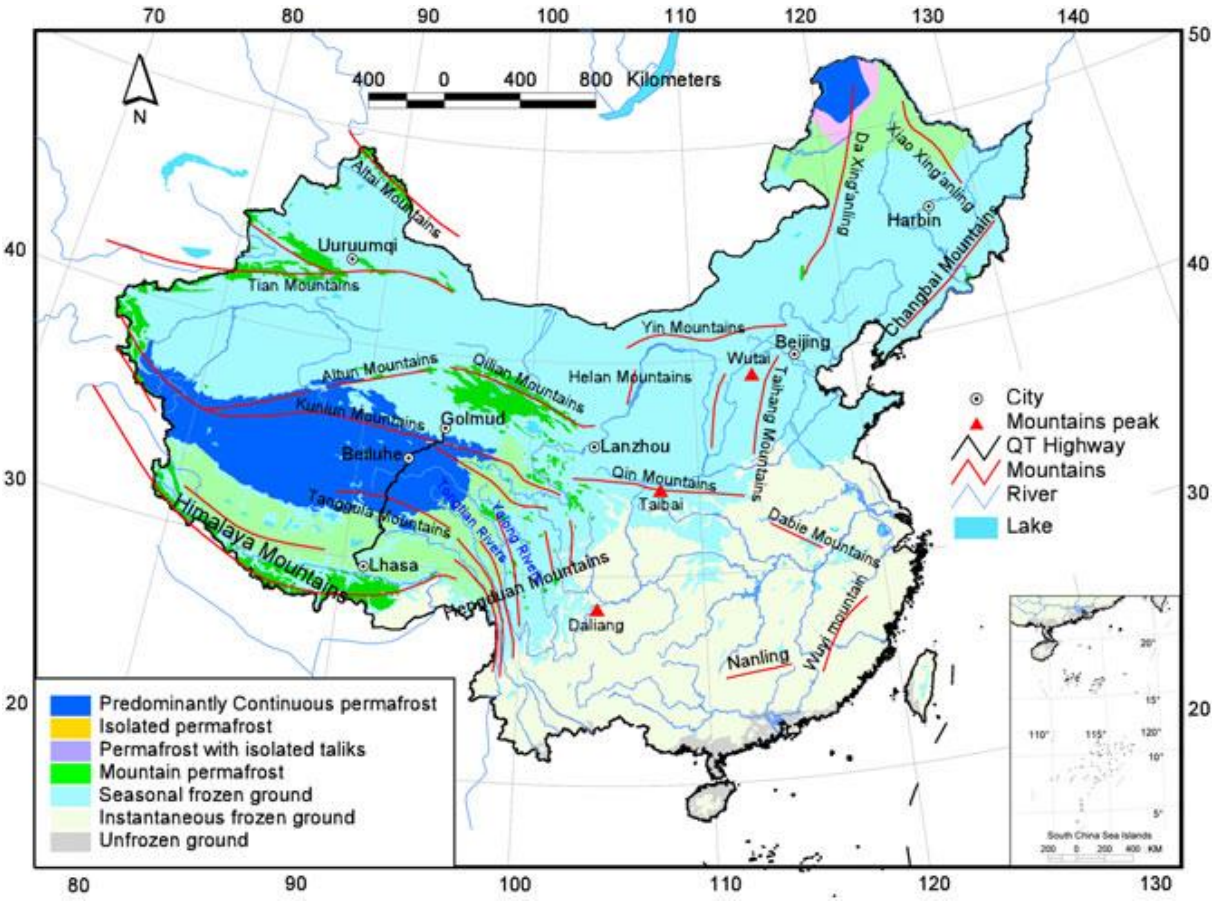

Figure 8 Distribution of frozen ground in the Map of Snow, Ice and Frozen Ground in China (Shi and Mi, 1988).

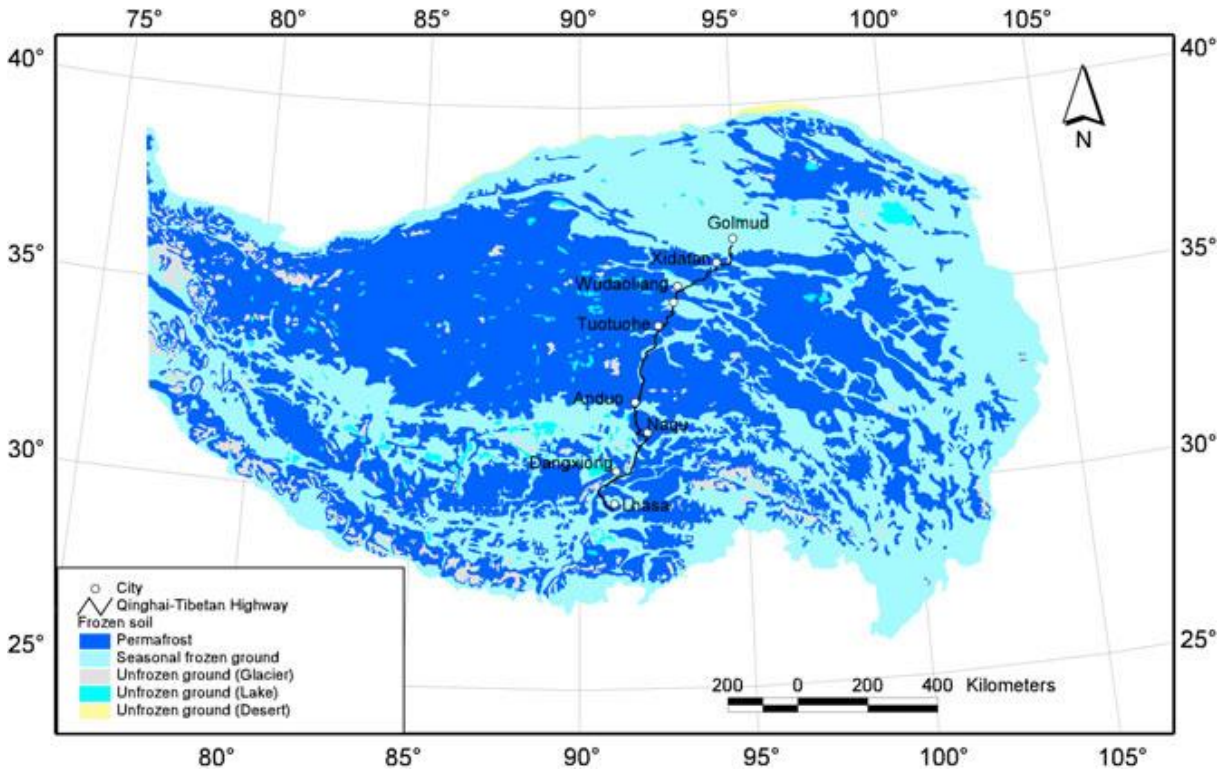

Figure 9 Frozen Ground Map of Qinghai-Tibet Plateau (Li and Cheng, 1996)

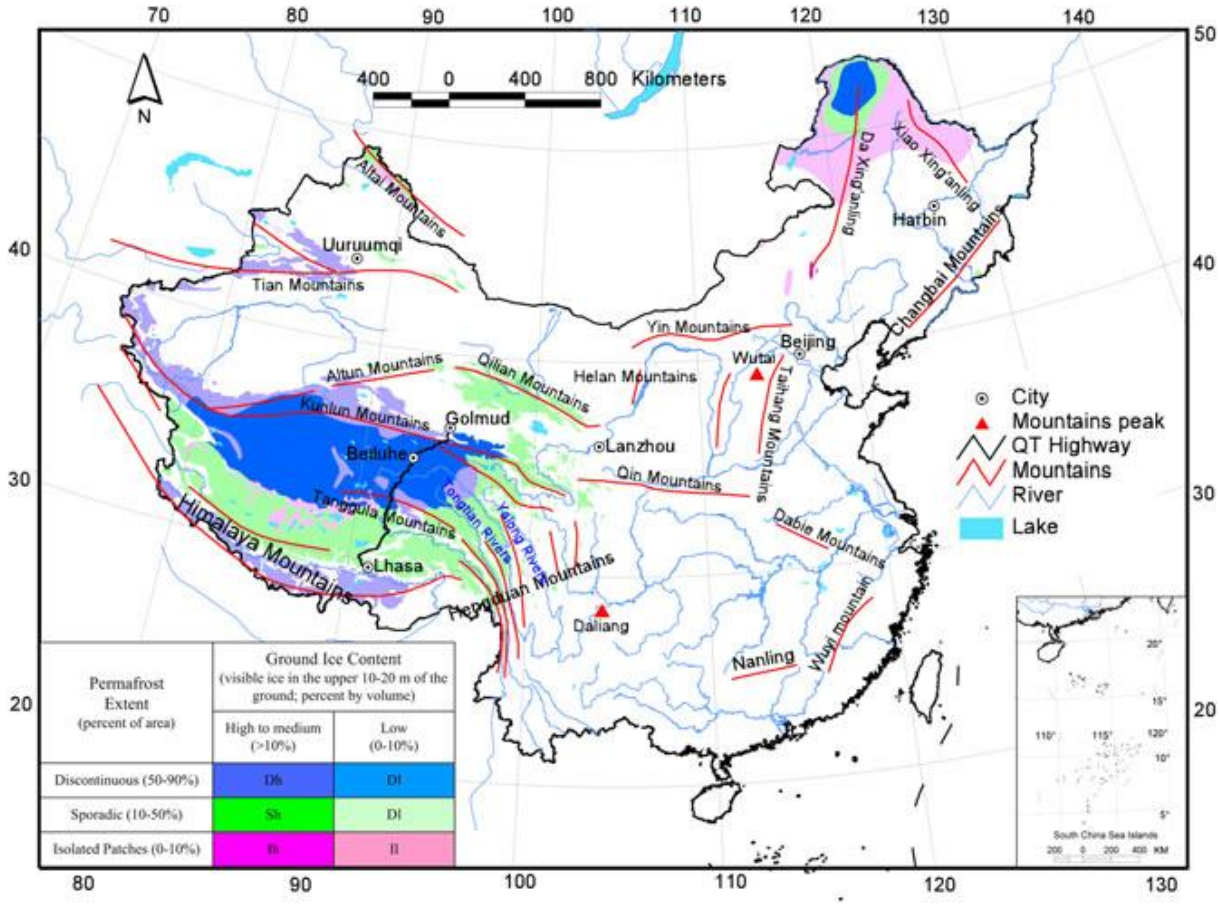

Figure 10 The China subset of the Circum-Arctic Map of Permafrost and Ground-Ice Conditions

compiled by the International Permafrost Association (IPA). Dondxin Guo and Guoqing Qiu were regional representatives for China in compiling the IPA map (Brown et al., 1997)

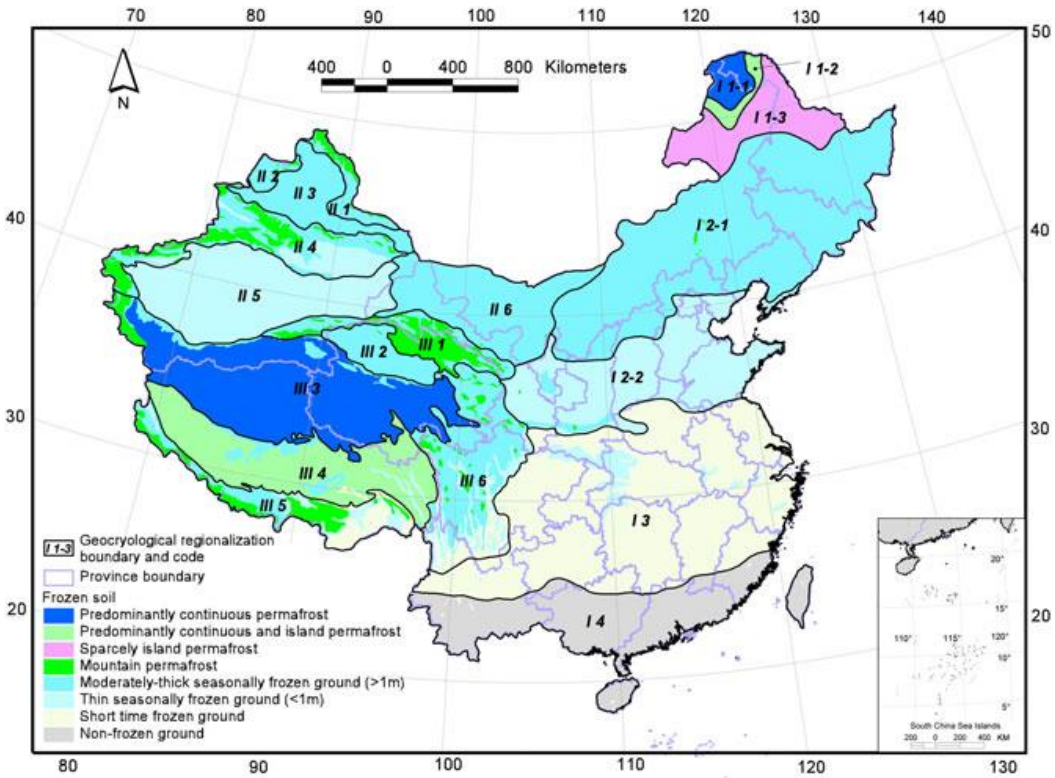

Figure 11 Map of Geocryological Regionalization and Classification in China (Qiu et al., 2000).

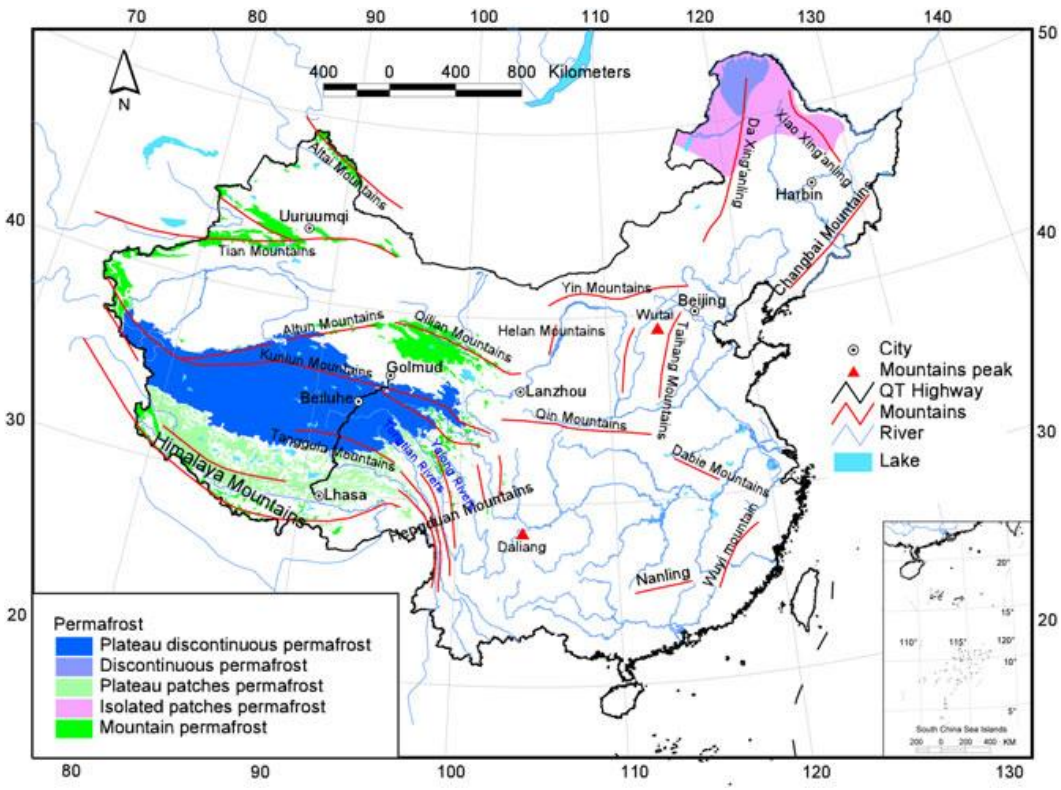

Figure 12 Distribution of permafrost in the Map of Glaciers, Frozen Ground and Deserts in China (CAREERI/CAS, 2005). QT= Qinghai-Tibet.

3.4 Near-Surface Soil Freeze/Thaw Cycles on Qinghai-Tibetan Plateau and in China

Changes in the near-surface soil freeze–thaw cycle on the Qinghai-Tibetan Plateau (QTP) were detected using daily soil freeze/thaw states derived from Special Sensor Microwave/Imager data from 1988 to 2007 (Li et al. 2012). The passive microwave remote sensing data used were the daily SSM/I data from 1988 to 2007 from the National Snow and Ice Data Center (http://nsidc.org/).

Because the near-surface soil freeze/thaw states change quickly with the soil temperature, the cold-overpass data were used in the early morning in order to capture the daily soil freeze–thaw cycles, specifically including the F8-SSM/I ascending data (6:00), F11-SSM/I descending data (6:00) and F13-SSM/I descending data (6:00). A dual-indices classification algorithm that uses the spectral gradient between the 37 GHz (TB,37v) and 18/19 GHz (TB,18/19v) brightness temperatures (SD) and

the 37 GHz vertical-polarization brightness temperature was applied to detect the freeze/thaw state of the surface soil.

A land cover map of China (Liu et al., 2005) was used to calibrate the dual-indices classification algorithm. The daily minimum ground surface temperature data from ground stations of the Chinese Meteorological Administration (CMA), located in regions of permafrost and seasonally frozen ground across China, were used to calibrate and validate the classification algorithm. The daily minimum ground surface temperature was measured at the soil surface. The estimated map is shown in Figure 13.

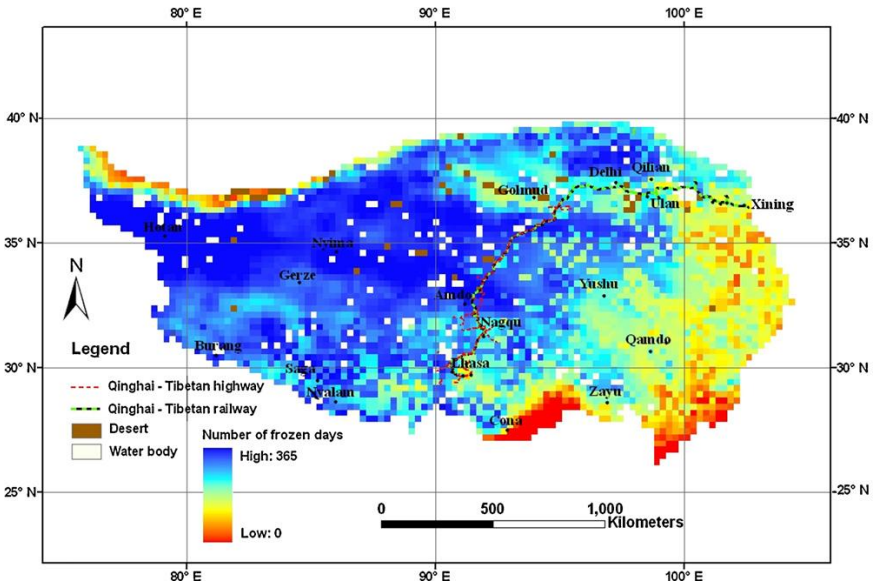

Figure 13 Mean number of frozen days between 1988 and 2007 on the Qinghai-Tibetan Plateau

Similar algorithm was applied to estimate the near-surface soil freeze/thaw cycles in China. As described in literature (Jin et al., 2009), based on the daily SMMR (1978-1987) and SSM/I (1987-2008) brightness temperatures with a 25 km spatial resolution, the dual-indices soil freeze/thaw algorithm, which uses the 37 GHz vertical-polarization brightness temperature and spectral gradient between the 37 GHz and 18/19 GHz brightness temperatures, is recalibrated for SMMR and SSM/I using the *in situ* daily minimal ground surface temperatures observed at 77 meteorological stations for each dominant land surface type. The daily classifications of surface soil freeze/thaw states are validated by data from another 273 meteorological stations.

The frozen soil classification accuracy, thawed soil classification accuracy and the total classification accuracy for the SMMR and SSM/I data are above 80% totally. Based on this dataset, as shown in Figure 14, the onset date of soil freeze in China is postponed 19.6±14.6 days, onset date of soil thaw is advanced -19.0±9.4 days, and the duration of soil thaw is shortened for 34.3±16.5 days.

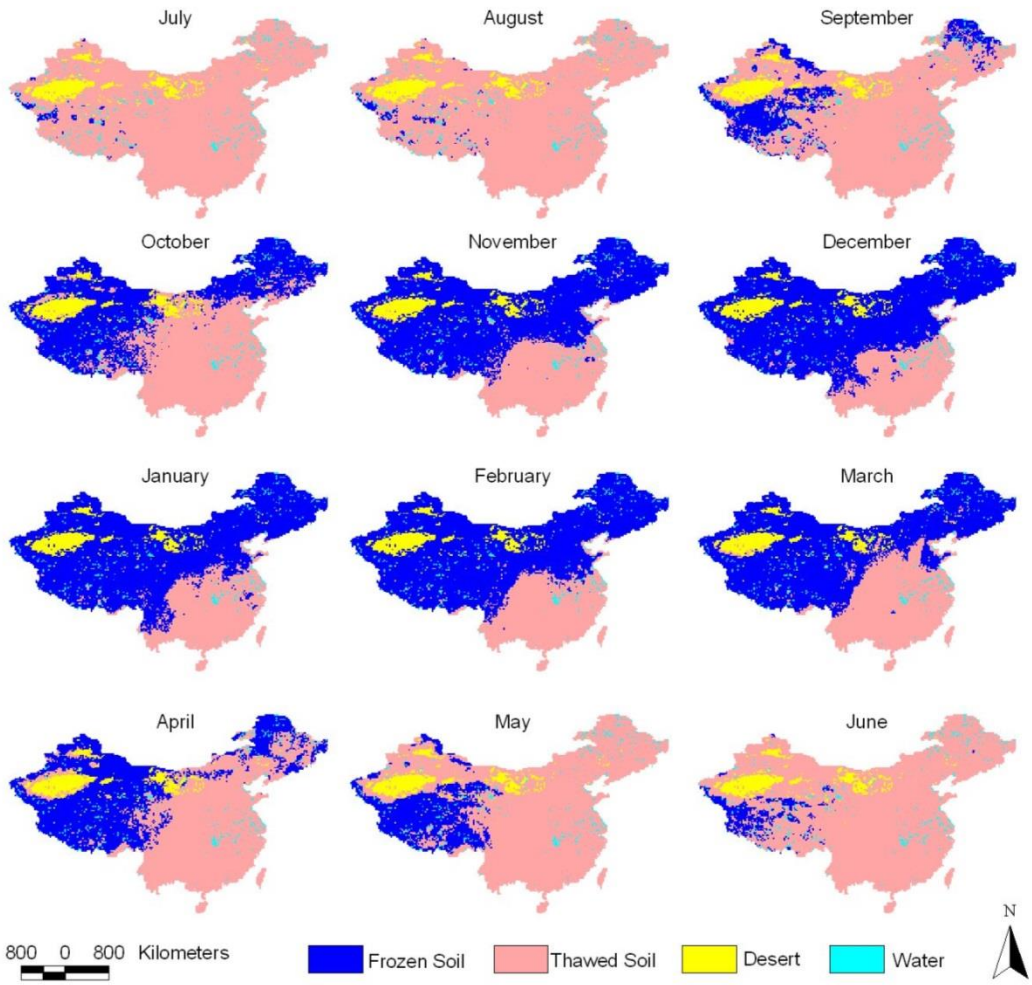

Figure 14 Monthly distribution of near-surface soil freeze/thaw status at 15th day of each month from July 1, 2001 -June 30, 2002

3.5 Long time series dataset of snow depth and snow water equivalent from SSMR and SSM/I in China

A long time series dataset of snow depth and snow water equivalent (SWE) from 1978 to 2005 in China was developed using passive microwave remote sensing including the Scanning Multichannel Microwave Radiometer (SMMR) and the Special Sensor Microwave/Imager (SSM/I) (Che and Li, 2005, Che et al., 2008). The data show that maximum annual SWE of about $17.8\times10^{9}m^{3}$ is located in Xinjiang and the western part of Inner Mongolia, $41.9\times10^{9}m^{3}$ on the QTP including the Pamir Plateau and the Qilian Mountains, and $36.2\times10^{9}m^{3}$ in northeastern China. The maximum areal extent of snow cover occurs in March, mid-January, and late February in the three above mentioned zones, respectively. The total maximum SWE of the three major snow covered regions in China is 95.9×10^{9} m^{3} yr^{-1}, which is about 10% of the normal annual discharge of the Yangtze River. Continuous snow cover existing for more than 60 days is about 3.4×10^{6} km^{2} and for more than 120 days about 1.5×10^{6} km^{2}. Figure 15 shows the distribution of averaged snow depth and continuous snow cover extent in China. The annual snowfall recharge was estimated to be over 3.45×10^{11} m^{3}.

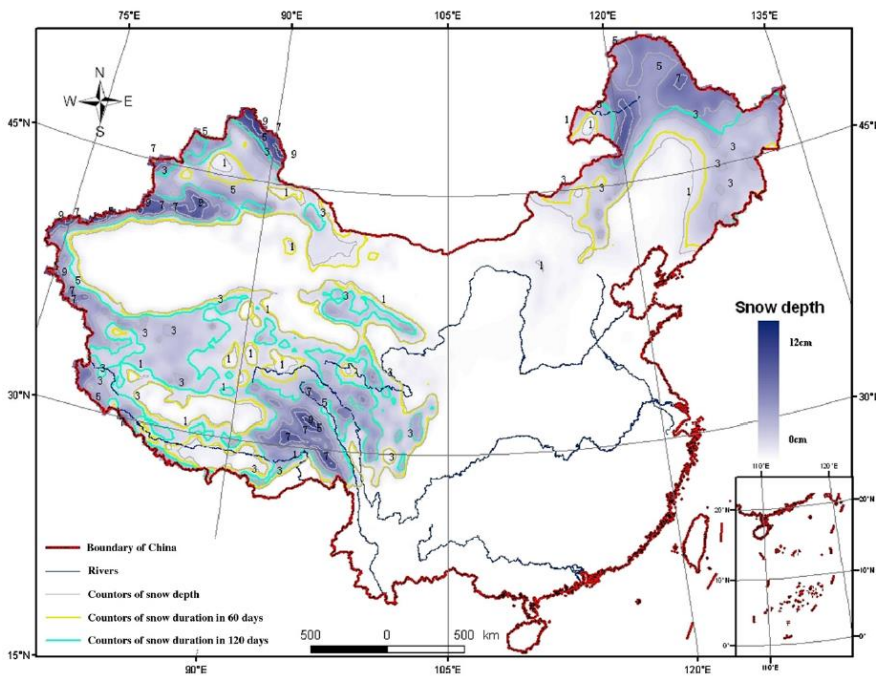

Figure 15 Distribution of snow in China

3.6 Long time series dataset of snow depth and snow water equivalent from AMSR-E in Xinjiang, China

Seasonal snow cover is very important to hydrological cycles and climate processes. For climate and hydrologic modeling, snow depth is a significant parameter. At present, passive microwave remote sensing is the most efficient way to estimate snow depth at the global and regional scales.

A long time series dataset of snow depth and snow water equivalent (SWE) was estimated from the Advanced Microwave Scanning Radiometer for Earth Observing System (AMSR-E) data (Dai et al. 2005), as shown in Figure 16. The brightness temperatures at 10.7 GHz, 18.7 GHz and 36.5 GHz of horizontal polarization were used to retrieve SWE, and that at 36.5 GHz of both vertical and horizontal polarizations were used to identify wet snow. To avoid possible snow-melt effects on brightness temperatures during the day, night-time overpasses were employed. A look-up table between snow properties and passive microwave brightness temperature at AMSR-E frequencies was established by using the MEMLS model, a microwave emission model of layered snowpacks, based on a priori snow characteristics, which can be obtained from field measurements and meteorological observations.

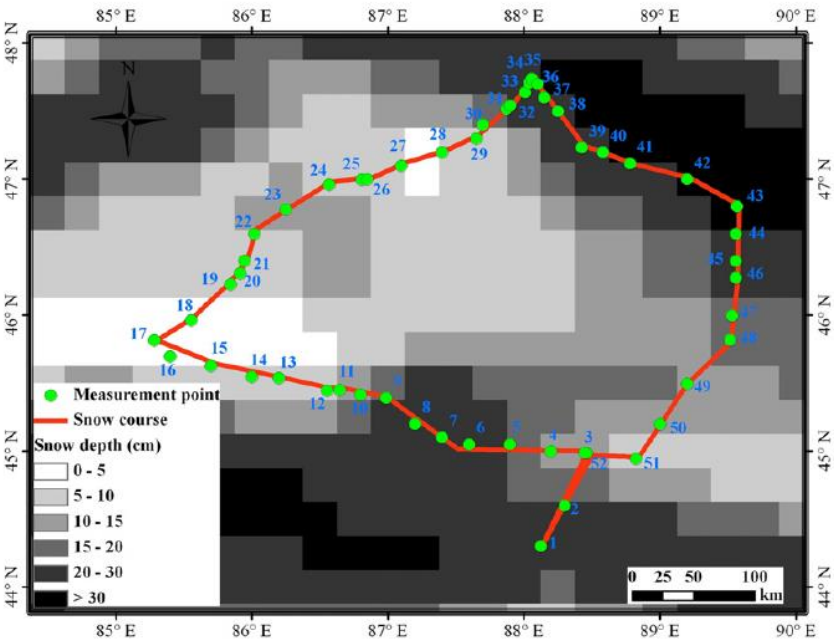

Figure 16 Snow depth map in Xinjiang, China

4 Summary

This paper introduced major databases, data centers and featured dataset on cryosphere in China. We expect those resources can be used by Chinese and global scientists. Data sharing is important and also difficult, particularly for precious cryospheric data which were collected from areas that are hard to reach at remarkable costs. We hope more and more scientists can share their data to data center and other scientists.

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